Abstract Submitted
for the DFD17 Meeting of
The American Physical Society

The Leaky Dielectric Model as a Weak Electrolyte Limit of an Electrodiffusion Model[1] YOICHIRO MORI, University of Minnesota, YUAN-NAN YOUNG, New Jersey Institute of Technology — The Taylor-Melcher (TM) model is the standard model for the electrohydrodynamics of poorly conducting leaky dielectric fluids under an electric field. The TM model treats the fluid as an ohmic conductor, without modeling ion dynamics. On the other hand, electrodiffusion models, which have been successful in describing electokinetic phenomena, incorporates ionic concentration dynamics. Mathematical reconciliation between electrodiffusion and the TM models has been a major issue for electrohydrodynamic theory. Here, we derive the TM model from an electrodiffusion model where we explicitly model the electrochemistry of ion dissociation. We introduce salt dissociation reaction in the bulk and take the limit of weak salt dissociation (corresponding to poor conductors in the TM model.) Assuming small Debye length we derive the TM model with or without the surface charge advection term depending upon the scaling of relevant dimensionless parameters. Our analysis also gives a description of the ionic concentration distribution within the Debye layer, which hints at possible scenarios for electrohydrodynamic singularity formation. In our analysis we also allow for a jump in voltage across the liquid interface which causes a drifting velocity for a liquid drop under an electric field.

[1]YM is partially supported by NSF-DMS-1516978 and NSF-DMS-1620316. YNY is partially supported by NSF-DMS-1412789 and NSF-DMS-1614863.

Yuan-Nan Young
New Jersey Institute of Technology

Date submitted: 01 Aug 2017 Electronic form version 1.4